

ATTACHMENT - REMARKS

INTRODUCTION.

In the "Attachment – Remarks" filed with the Amendment on November 18, 2009, a misunderstanding was made in the arguments concerning the formula noted therein. In particular, the previous arguments in the "Attachment – Remarks" were based on a misunderstanding that the $\frac{3}{2}\alpha_2$ term dominates the spring's contribution to the timekeeping change formula for a CuBe spring as discussed therein. This is not correct, it was realized shortly thereafter. In fact it is the $\frac{\delta E}{E}$ term portion that dominates. In light of this later discovered misunderstanding and in order to provide correct arguments, it is requested that the previous arguments be disregarded and replaced with the arguments in the following Remarks section.

It is considered that the simplest manner to accomplish this substitution of arguments is to provide a new Remarks section to replace the entirety of the "Attachment – Remarks" section that was filed on November 18, 2009 (although some of the same discussions and arguments remain the same). Therefore, it is requested that the following Remarks section, and in particular the following discussions and arguments, be considered and the previously filed "Attachment – Remarks" not be considered or considered to have been superseded by the following Remarks.

It will be noted that the claim amendments previously made in the Amendment filed on November 18, 2009 and entered are still desired and appropriate, so it is only

the "Attachment – Remarks" filed on November 18, 2009 which are hereby being superseded.

REMARKS.

By the Amendment (filed on November 18, 2009), independent claims 77 and 90 (and similarly withdrawn but re-joinable independent claim 93) have been amended to better define the invention. In addition, consistent amendments were made in various dependent claims, while dependent claim 85 has been canceled. It is submitted that the present application is in condition for allowance for the following reasons.

In the *Claim Rejections - 35 USC § 102 and § 103* sections of the outstanding DETAILED ACTION, independent claims 77 and 90 together with associated dependent claims 78-85, 87-89 and 91-92 were all rejected as being anticipated by or obvious over Biemiller. However, for the following reasons, it is submitted that all of these claims are allowable over this reference.

Initially, it will be appreciated that the amendments to independent claims 77 and 90 incorporate the subject matters of dependent claims 78 (in part) and 85. The distinction now provided from Biemiller by these changes is that the balance wheel of the present invention includes a balance arm of a non-magnetic material having a thermal expansion coefficient (CTE) of less than $6 \times 10^{-6} \text{ K}^{-1}$. Section 5 of the final Office Action acknowledges that this feature is not disclosed in Biemiller, but alleges that it would have been obvious at the time the invention was made to arrive at this feature. The reason given by the examiner is that this feature is allegedly "an optimum value of a result effective variable", which is discovered through the application of routine skill in

the art. This argument does not take into account all of the factors relevant to the selection of material for the balance wheel arm in a thermally compensating system, as explained below.

A skilled person contemplating optimization of the Biemiller arrangement would not consider the CTE of the balance arm as an area for optimization because it has a negligible effect on the thermal compensation mechanism in a system with a thermally unstable spring. Biemiller proposes the use of a thermally unstable CuBe spring, which has a CTE¹ of $17.6 \times 10^{-6} \text{ K}^{-1}$ and an average value of $\frac{\delta E}{E}$ in the ambient range of $-2.95 \times 10^{-4} \text{ K}^{-1}$. The timekeeping change formula [5] on page 8 of the present application is:

$$U = \alpha_1 - \frac{3}{2} \alpha_2 - \frac{1}{2} \frac{\delta E}{E}$$

where: U is the time change consequent on a rise in temperature of 1°C ,

α_1 is the balance wheel CTE,

α_2 is the spring CTE,

$\frac{\delta E}{E}$ is the ratio of change in Young's modulus consequent on the 1°C

temperature rise to Young's modulus.

From this formula, it would be understood by the skilled person that the $\frac{\delta E}{E}$ term

dominates. Compensation for the $\frac{\delta E}{E}$ term is achieved by applying a compensating

¹ See the table at the bottom of page 6 of the attached "Guide to Beryllium Copper" (multiplying the CTE value by 5/9 to equate to $^\circ\text{C}$ standard); any standard reference; or e.g., USP 5895533, figure 3.

mechanism to the balance wheel to reduce its moment of inertia with an increase in temperature, i.e., by providing it with an effectively negative CTE. In Biemiller this compensating mechanism comprises the bimetallic arms loaded with weights, which bend inwards with an increase in temperature.

To illustrate, consider the situation where the balance wheel is a disc of pure CuBe. Substituting values for α_1 , α_2 and $\frac{\delta E}{E}$ into the timekeeping change formula yields:

$$U = [17.6 - \frac{3}{2}(17.6) - \frac{1}{2}(-295)] \times 10^{-6} = 138.7 \times 10^{-6}$$

which over a day (86,400 seconds) yields a time error of 12.0 seconds. To compensate for this, the effective CTE of the balance wheel must be $-156.3 \times 10^{-6} \text{K}^{-1}$. The bimetallic arms in Biemiller are thus required to provide an enormous compensating effect that is an order of magnitude greater than the CTE of the balance wheel material.

Accordingly, a person skilled in the art interested in optimizing the Biemiller arrangement would take no account whatsoever of the balance arm, because its contribution to the compensating mechanism is negligible compared with the behavior of the spring and bimetallic arms. Indeed, already in Biemiller it is clear that the CTE of the balance arm is not an important factor because the CuBe frame 20 also includes the enclosed synthetic resin members 26, 34, the coil, and the heavy metal studs 36. These extra components actually act to increase the effective CTE of the balance wheel. Accordingly Biemiller actually teaches away from the claimed subject matter, which suggests reducing the CTE of the balance arm.

A person skilled in the art interested in optimizing the Biemiller arrangement

would actually look to optimizing the spring material or the bimetallic arms in order to improve the disclosed arrangement.

The present invention is based on the discovery that where a thermally stable non-magnetic spring is used in a mechanical oscillator, reducing the CTE of the balance arm can improve the system. Even in a thermally stable system, the compensating effect is provided primarily by a reduction of the moment of inertia of the balance wheel. However, the magnitude of the reduction required may be less than is needed in the thermally unstable situation. Minimizing the CTE of the balance arm may reduce the compensation required in a non-negligible manner. One result of this is an improvement in the physical stability of the balance wheel because the magnitude of the mass moved by the compensating mechanism and/or the distance it needs to move can be minimized. With a thermally unstable spring arrangement, the magnitude of the moment of inertia change required of the balance wheel is so great that reducing the CTE of the balance arm would have no improving effect on the physical stability of the oscillator. There is therefore no teaching or suggestion to prompt the person skilled in the art to arrive at the subject matter of current claim 77 (or 90 or withdrawn 93).

The results of the inventor's own research degree (which were not in the public domain when this invention was conceived) indicate that the magnitude of $\frac{\delta E}{E}$ for a thermally stable continuous carbon fibre material suitable for manufacturing a balance spring (as disclosed in the applicant's earlier US patent application serial number 10/520,926, now "ready to issue") is $12.4 \times 10^{-6} \text{K}^{-1}$ which is more than 20 times less than the magnitude of the $\frac{\delta E}{E}$ term for the thermally unstable CuBe spring disclosed in

Biemiller. There is no disclosure in the cited prior art of such low values for the thermal evolution of Young's modulus in balance spring materials. As demonstrated by the arguments above, in the absence of such a disclosure, the contribution of the balance arm CTE to the compensation mechanism would have been regarded by the person skilled in the art as negligible and substantially irrelevant to compensation. It would not have been obvious to optimize it at all, let alone alter it to arrive at the subject matter of current claim 77.

Therefore, for all of the foregoing reasons, it is submitted that amended independent claims 77 and 90 (and withdrawn 93) are neither disclosed nor made obvious by Biemiller so that these claims are now allowable. And for at least these same reasons, it is submitted that claims 78-84, 86-89, and 91-92 dependent from these independent claims are also allowable.

In the Allowable Subject Matter section, it was (again) indicated that dependent claim 86 contained allowable subject matter. This indication of allowable subject matter is appreciated. It is submitted that claim 86 is now allowable based on its dependence from now-allowable independent claim 77.

For all of the foregoing reasons, it is submitted that the present application is in condition for allowance and such action is solicited.

Respectfully submitted,

Date: December 3, 2009

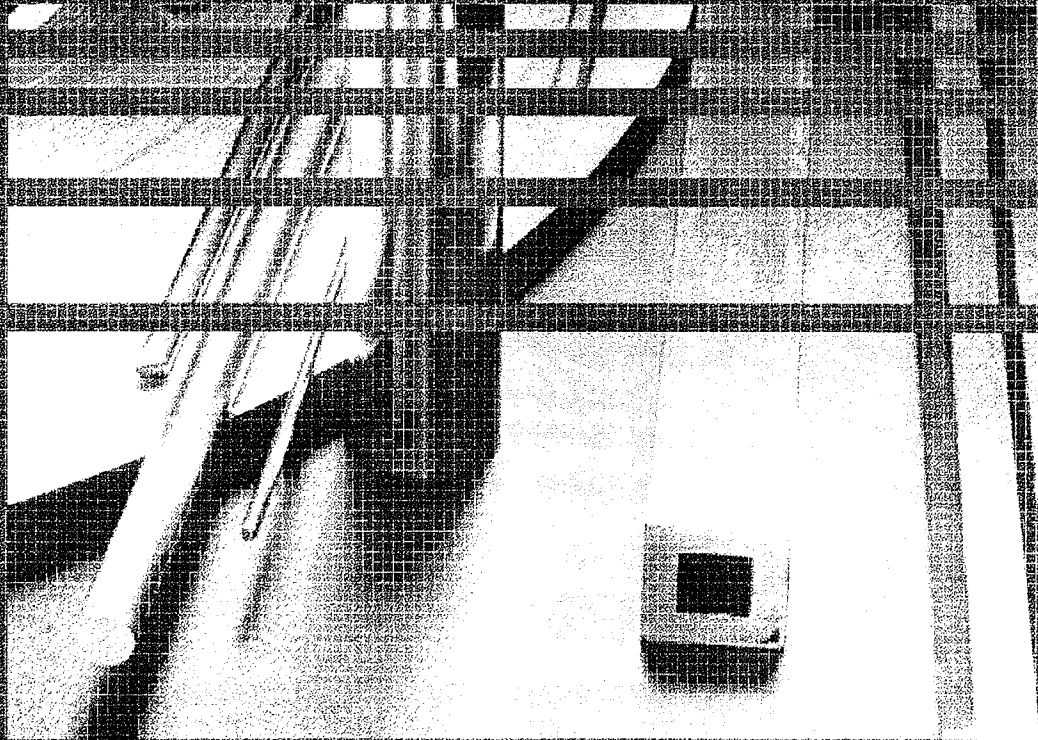
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"Guide" Attachment to Amendment
Cover and pages 6 and 38

Guide to Beryllium Copper



BRUSHWELLMAN
ENGINEERED MATERIALS

Alloy Guide

produced to the user's specification and are supplied in straight lengths.

Forgings, made from cast billet, are supplied in forms ranging from simple geometric configurations to near-net shapes according to user specifications.

Custom fabricated parts are supplied to customer drawings as finished or semi-finished parts. Such products are fabricated from basic product forms (rod, extrusions, plate, etc.) by processes such as ring rolling, forging, welding, and machining.

Physical Properties

Beryllium copper's physical and mechanical properties differ considerably from those of other copper alloys because of the nature and action of the alloying elements, principally beryllium. Varying the beryllium content from about 0.15 to 2.0 weight percent produces a variety of alloys with differing physical properties. Typical values of some of these properties are presented in the table on this page.

Whether a high strength or a high conductivity alloy, some physical properties remain similar. For example, the elastic modulus of the high strength alloys is 19 million psi; for the high conductivity alloys, 20 million psi. Poisson's ratio is 0.3 for all compositions and product forms.

A physical property that differs significantly between alloy families is thermal conductivity, which ranges from about 60 Btu/(ft·hr·F) for high strength alloys to 140 Btu/(ft·hr·F) for the high conductivity grades. The thermal and electrical conductivities of beryllium copper promote its use in applications requiring heat dissipation and current carrying capacity. Electrical conductivity is listed with mechanical properties in the Product Guide section of this book.

The thermal expansion coefficient of beryllium copper is independent of alloy content over the temperature range in which these alloys are used. The thermal expansion of beryllium copper closely matches that of steels including the stainless grades. This insures that beryllium copper and steel are compatible in the same assembly.

Specific heat of beryllium copper rises with temperature. For Alloys 25, M25 and 165, it is 0.086 Btu/(lb·F) at room temperature, and 0.097 Btu/(lb·F) at 200 F. For Alloys 3, 10 and 174 it rises from 0.080 to 0.091 Btu/(lb·F) over the same temperature range.

Magnetic permeability is very close to unity, meaning that the alloys are nearly perfectly transparent to slowly varying magnetic fields.

Beryllium copper high strength alloys are less dense than conventional specialty coppers, often providing more pieces per pound of input material. Beryllium copper also has an elastic modulus 10 to 20 percent higher than other specialty copper alloys. Strength, resilience, and elastic properties make beryllium copper the alloy of choice.

Typical Physical Properties					
Brush Alloy	Density lb/cu in.	Elastic Modulus 10 ⁶ psi	Thermal Expansion Coefficient in./in./°F, 70°F to 400°F	Thermal Conductivity Btu/(ft·hr·°F)	Melting Temp. °F
25 M25	0.302	19	9.7×10^{-6}	60	1600-1800
165	0.304	19	9.7×10^{-6}	60	1600-1800
3	0.319	20	9.8×10^{-6}	140	1900-1980
10	0.319	20	9.8×10^{-6}	115	1850-1930
174	0.318	20	9.8×10^{-6}	135	1880-1960

Note: Tabulated properties apply to age hardened products.
Before age hardening the density is: 0.298 lb/cu.in. for Alloys 25, M25 and 165; 0.316 lb/cu.in. for Alloys 3 and 10